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Physiologic Specialization of *Synchytrium endobioticum*

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In a review published in 1931 of the existing knowledge concerning potato wart disease and its causal fungus *Synchytrium endobioticum* (Schilb.) Perc., KÖHLER (17) rejected the idea that the disease is caused by different physiologic races of the pathogen. He stated that the fungus species is very uniform in characteristics and that there are no indications of racial differenciation. This view was based mainly on observation that wart-resistant potato varieties had remained resistant in all disease-affected areas of the world and susceptible varieties were universally liable to attack. Breeding for resistance to potato wart was very successful and was considered as an outstanding example of disease control through breeding. The wide dispersion of a uniform causal fungus was also confirmed by three German laboratories where the fungus and fungus mixtures from different sources were studied without finding any remarkable differences (24).

Ten years later potato varieties considered as wart-resistant were attacked for the first time in central Germany. Another ten years later new biotypes were reported from the Federal Republic of Germany, Italy, Czechoslovakia and the U.S.S.R. These findings roused much attention to the problem of potato wart disease throughout the world and changed the concept that physiologic specialization does not exist in *Synchytrium endobioticum*.

Occurrence and Spread of New Biotypes

It is difficult to obtain a complete record on the occurrence of new biotypes of the potato wart fungus, for many countries are presumably reluctant to report their existence. This reluctance is not only due to commercial consideration, but also to the fact that when a new wart outbreak occurs it is difficult to decide without further work whether or not a new biotype is involved. This is especially so where a common susceptible potato variety is grown. In many cases the varietal identity may not be known and occasionally susceptible varieties may be found in places where the cultivation of such varieties is prohibited, as was observed in the Netherlands. Sometimes even old varieties of unknown origin may be found still in cultivation (13, 1, 2). When the new biotype appeared in Thuringia, central Germany, of the 165 diseased samples taken from the infested field, 148 could be traced to varieties susceptible to wart (24), although the field was located in an area where only resistant varieties were allowed to grow. The problem is complicated by the possibility of varietal mixtures as well as the necessity of proving the existence of a new biotype through field tests of several years. There may also be differences between results obtained in the laboratory and in the field. BJÖRLING (8) reported that 14 new varieties were found resistant in laboratory tests but one of them became heavily infected when planted in the field. HEY (14) also recorded differences in results between laboratory and field tests concerning a new biotype of *Synchytrium endobioticum*.

New biotypes of *Synchytrium endobioticum* have so far been found in Germany always in regions which were previously known as potato wart infested. The geographic limita-

tion known for the normal potato wart fungus applies also to the new biotypes. The areas of occurrence are always mountainous areas with relatively high rainfall, where small helders grow potatoes in the same fields for many years using their own crop for seed. The lack of rotation and of new supply of seed potatoes leads to a high concentration of the fungus, which under these favorable conditions may cause great damage and sometimes complete failure of the crop.

BRAUN (11) reported in 1942 the first occurrence of a new biotype in Giessübel (Thuringia), shortly after BLATTNY (10) published a paper on a new race of the wart fungus in Budweis (Southern Bohemia), Czechoslovakia. In Giessübel the variety Ostbote, which was certified as wart-resistant and which was clearly identified, was attacked. In 1942 the varieties Ackersegen, Flava and Ostbote were infected in Klein-Schmalkalden (Kreis Gotha, Thuringia), today known as Pappenheim, about 42 kilometers from Giessübel in air distance (12). Further findings were reported in central Germany from Rudolstadt (Thuringia) in 1950 and from Koppatz (Kreis Kottbus) in 1951 (15). In the Federal Republic of Germany outbreaks were reported in Dorsten (Kreis Recklinghausen) in 1950 and in Dortmund-Mengede one year later (26). In 1953 there were further outbreaks of biotypes in Westphalia in the Kreise Olpe, Siegen and Altena (27). From the reports of the German Plant Protection Service (4) it was noted that a focus occurred in Schweinsberg (Hesse) in 1953 and another one in the Kreis Fulda (Hesse) in 1954. Finally an outbreak was reported in 1955 in Forbach (Kreis Rastatt) in the Black Forest, on a so far resistant potato variety grown in a small isolated area (5).

From other countries, little information is available. In Italy, LORENZINI (21) reported in 1952 a heavy but typical attack of the variety Ackersegen near Milan, whereas the variety Voran was not attacked. In U.S.S.R., Potlajčuk (22) reported in 1951 biotype foci in Minsk, Chernovtsy and Leningrad. In Czechoslovakia, according to ZAKOPAL (29), there seem to be, in addition to the biotype reported from southern Bohemia, other biotypes in other places. The varieties Carmen and Reneta were attacked in Svermow but not in Velké karlovice. Surveys and field tests in Austria along the Czechoslovakian border, on the other hand, failed to reveal the existence of new biotypes of the potato wart fungus (6). In Sweden an extensive test with diseased materials from 16 newly found foci of potato wart in the southern and central parts of the country showed that new biotypes probably did not occur (9, 20). As indicated in a recent brief account on the spread of the potato wart disease in Finland, new biotypes were not known in that country (28). In addition to the foregoing, EPPO (6) reported the absence of new biotypes in the following countries: France, United Kingdom, the Netherlands, Norway, Austria, Portugal.

There is no doubt that the foci of new biotypes often existed several years before they were discovered. Especially in Thuringia, because of the cultivation of the normally susceptible varieties, there was the possibility of confusing the new biotype with the only biotype then known. At the time when the new biotype was eventually discovered several hectares had been already attacked (16). After two years of control efforts it was revealed in Giessübel (Thuringia) that the infestation of the arable land was still widespread, at which time it was too late to stop completely the cultivation of potatoes. In any event, such a measure would not have stopped the spread of the disease as the causal fungus can be spread by cattle, wildlife and cultural practices. It is thought that a few scattered foci of potato wart in this infested area could be due to the movement of wildlife from one place to another. Giessübel is considered today to be completely infested and the disease has spread further to six adjacent communes. Since 13 hectares of a total of 23 hectares of potatoes in Giessübel were already planted in 1947 with Fram, a resistant variety, it was easy to prohibit in 1948 the planting of varieties susceptible to the new biotype (12). In Pappenheim the infested fields increased from 2 percent in 1945 to 8 percent in 1946, and the actual infested area might be even higher. Today four communes are infested in this region. Situated in the Bezirk of Suhl are communes suspected of being infested by the new biotype. The outbreaks of the Giessübel biotype in Rudolstadt and Koppatz have been localized by severe measures (16). This is the situation in central Germany so far as

known today. The occurrence of new biotypes in West Germany has been known only in recent years; consequently the difficulties in the continuous application of control and preventative measures due to the war conditions, such as encountered during the first years in Thuringia, do not exist here.

The first focus in West Germany at Dorsten is now completely localized, the whole infested area being sown with grasses. The focus at Dortmund-Mengede is confined to a small field surrounded by woods and moors without connection to other agricultural land. In the tiny focus discovered in the Black Forest there is the possibility of abandoning potato growing completely. Therefore, these outbreaks are of no practical importance.

More important is the outbreak in the Sauerland area of Westphalia where, in addition to heavy infestation during past years, some spread has occurred. In the Kreise Olpe and Siegen, of 4,600 hectares of potato, approximately 34 hectares are infested today, the original estimate of 850 hectares being much too high (3). The situation in Hesse is not yet clear and some individual foci require further examination (5). The more extensive infestation is in the commune of Schweinsberg (Kreis Marburg), where potato cultivation at the original focus could be abandoned, and it is planned to establish forests in this swampy area. The infestation in Fulda is well localized.

As far as the foci in Italy, U.S.S.R. and Czechoslovakia are concerned, no further detail is known. The infestation in southern Bohemia described by BLATTNY could have been eradicated (16).

Biotype Analysis

In 1942 BRAUN (11) published preliminary results on reactions of differential varieties of potato to the common biotype D(= Dahlem), the new biotype G(= Giessübel) from Thuringia and the biotype from southern Bohemia that BLATTNY had sent to the *Biologische Bundesanstalt* in 1941. Shortly before BRAUN'S publication, BLATTNY (10) had established the geographic distribution of these three races in central Europe, but this attempt was obviously premature. It is certainly incorrect for BLATTNY to include in his consideration varieties such as Rode Star and to assume that the classification of these varieties as wart-susceptible in some countries but as resistant in others, would indicate the existence of biotypes. It is in fact a question of varieties with inert reaction; such varieties must be classified as an intermediate type which produces different reactions according to the prevailing local conditions.

The preliminary investigations of BRAUN (11) showed that biotype G attacked all the six differential varieties except Fram, whereas the biotype from Czechoslovakia which was called biotype SB(= Südböhmen) attacked only three varieties. Tests on a larger set of differential varieties showed that only Fram and Frühe Hörnchen out of 67 varieties were resistant to biotype G, but only 13 varieties out of 66 were really attacked by biotype SB. BRAUN at that time used already the now often quoted expression " high aggressiveness " for biotype G; this expression refers however primarily only to the differential potato varieties. The German set of differential varieties represented, even in 1942, a selection of varieties resistant to the only biotype of potato wart then known, now designated as biotype D.

After the potato wart outbreak in Pappenheim (Schmalkalden), it was impossible, even through the testing of 700 potato varieties and selections, to separate clearly this isolate from biotype G. This would prove its identity with biotype G (12).

The other two biotypes from central Germany, i. e., Rudolstadt and Koppatz, when tested on differential varieties including Mira, Deodara, Robusta, Carnea, Sickingen and Parnassia and a selection, proved to be distinct biotypes. HEY (16) established the reactions of different varieties as follows:

a) susceptible to all biotypes: Deodara
b) resistant to biotype D but susceptible to all others: Robusta
c) react differently to various biotypes: Carnea and the selection
d) resistant to all biotypes: Mira

In West Germany, the variety Ackersegen is used for Robusta, and Nova, Urgenta and selections for varieties with different reactions

to biotypes. Some selections have proved to be resistant against all biotypes. It is impossible to establish a differential host set exclusively from the German commercial varieties which are resistant to biotype D and therefore selections must be included.

EPPO (6) reported that at least four different biotypes have been identified in the Federal Republic of Germany. Investigations show that there must be several biotypes but it cannot be assumed that each outbreak in which potatoes resistant to biotype D are attacked is due to an entirely new biotype. Earlier field tests established at the centers of infection were aiming primarily at the discovery of a worthy resistant variety which would eliminate quickly the infection centers.

Differences between the fungus from Westphalia and that from Hesse were observed. Laboratory tests to establish a set of differential varieties were initiated in the winter of 1955-56 and field tests for the analysis of biotypes began in 1956; it is too early to yield conclusive results.

In the field tests carried out during the first three years after the occurrence of the new biotype in Westphalia, the varieties Monika and Falke were attacked in Dortmund-Mengede and Olpe but not in Dorsten, but 75 other varieties showed consistent reactions in all three localities (29). The variety Falke and probably also Monika, as later tests have shown, are of the type with inert reaction and, because of their inability to produce excrescences, they are unsuitable as differential hosts. Furthermore, the resistance of these two varieties at Dorsten was based on the observations of one year only and the focus of infection had been eliminated; therefore it could not be decided if the biotype found at Dorsten was identical with any of the others occurring in Westphalia.

In the Netherlands the biotype from Olpe is called "physio G" (Giessübel) without having sufficient proof of its identity with the biotype G (2). Although the varieties resistant to biotype G are not infected by the biotype from Westphalia, it seems probable according to preliminary research that these two biotypes can be separated through a potato selection. Therefore the biotype from Olpe should not be called "physio G."

The nomenclature of the biotypes of *Synchytrium endobioticum* is not clear. The most common biotype D has been designated also as biotype A (7) or biotype 1 (16). As it would be impossible to keep the letter designation for long, it might be recommended to adopt a system designating the biotypes with numbers as for the *Phytophthora* strains. In this case biotype D would be number 1, biotype G number 2, biotype SB number 3, biotype Rudolstadt number 4, biotype Koppatz number 5, and biotype Olpe, when its identity becomes clearly established, number 6. Numbers 7 and 8 would be reserved for the two probably distinct biotypes from Schweinsberg and Fulda in Hesse, West Germany. Even without identification of biotypes on the basis of tests with differential varieties, these designations could be used for practical purpose.

Resistance to Biotypes

Very little is known about the genetics of resistance against new biotypes of potato wart fungus, but it seems to be more complicated than that of resistance against biotype D and seems to depend on several genes (7). The wild species *Solanum aracc-papa* and varieties of *S. demissum* have proved to be resistant against biotype G (15, 16).

The first tests on resistance against biotype G included about 300 domestic and foreign potato varieties. Preliminary results showed that varieties Fram, Frühe Hörnchen and Priegnitzstärke were resistant, and later the resistance of varieties Fontana, Hilla and Mira was also proved. Hilla and Mira are at present still of commercial importance. Other approved varieties of West Germany, which proved to be resistant, are Fortuna and Hochprozentige. Of special interest is the laboratory test on the resistance to biotype G of potato selections from the former Institute of Biology of Dahlem. Among 677 selections, 226 were resistant, including the cross No. 9089 which has been used in the breeding of a few resistant varieties (14). In 1954 HEY (16) listed 98 selections of outstanding agronomic value.

The earlier field tests in Westphalia were not encouraging. In the winter of 1954 infected material of the biotype from Westphalia was sent to the Netherlands Plant

Protection Service in Wageningen for laboratory tests, in which about 20 percent of a total of 536 samples tested were found to be resistant (2). In similar tests in Westphalia the varieties Hilla, Fortuna, Fram and Fontana were also free from infection. Large-scale tests were initiated in 1953 to determine the susceptibility of 3,150 potato selection to the biotype from Westphalia (3).

The official potato wart test in Germany, based on the Order for the Control of Potato Wart of 1937 and 1939, still depends on the resistance against biotype D. The localization of the foci of new biotypes makes it possible that the testing of resistance to new biotypes may be carried out on a voluntary basis to meet the practical requirement in breeding work. After sufficient testing, biotype resistance can be certified and it is considered as an additional asset in the official approval of new varieties. Only potato selections which are absolutely free from warts in the field tests are regarded as wart-resistant.

Physiological Characteristics of New Biotypes

Since field tests have been undertaken in biotype-infested areas, discrepancies have arisen when comparing the results with laboratory results. When large-scale tests are carried out, the older laboratory method of SPIECKERMANN (25) has to be used, but it seems to yield discrepancies more frequently in results than the method of LEMMERZAHL (19) which is not based on resting sporangia but on summer sporangia. But the LEMMERZAHL method is also not fully satisfactory as it does not achieve the objective of using a uniform inoculum.

HEY (14) has investigated, in the case of biotype G, the cause of the differences of laboratory tests according to LEMMERZAHL'S method and field tests. When working with biotype D it was already necessary to make field tests with varieties which are inconsistent in reactions. Occasionally resistant varieties with a relatively high grade of infection and a high grade of reaction may produce excrescences. It is difficult to establish the limits of the variation of "labile" (unstable) varieties, because varieties of the marginal type were specially susceptible to environmental factors.

According to KÖHLER (18) a low grade of infection[1] in laboratory tests is always correlated with field resistance, but varieties with a high grade of infection in the laboratory will be resistant in the field only if the grade of reaction of the host is low. This rule is, however, not applicable to biotype G, as shown by the investigations of HEY (14) who compared laboratory tests in two years at Giessübel. In those cases even when the grade of infection was low in laboratory tests, tumors might be developed in the field. Under conditions particularly favorable for infection, potatoes with a very low grade of infection (grade I according to KÖHLER) could produce very small tumors in the field. This shows that even if sori occur only occasionally after infection by biotype G, a check of the laboratory results with field results is necessary. In the investigations made so far, the complete lack of sori in the laboratory is always an indication of resistance in the subsequent field tests. The contrary, that a variety with a high grade of infection in the laboratory shows resistance in the field, is unlikely to happen. Should it happen, the conditions for infection in the field are probably unsatisfactory.

HEY (14) also shows that biotype G produces in many potato varieties and selections a lower grade of infection than the common biotype D and that the affected potatoes are less liable to necrogenic abortion. This observation relating to the lower grade of infection with biotype G, however, cannot be generalized. At least with one selection from West Germany the same grade of infection as with biotype D was obtained with biotype G, if not higher.

HEY'S investigations have been confirmed by SASS (23) who was also unable to explain the lower grade of infection produced by biotype G. In his tests the infection and

[1] Five infection grades were differentiated by KÖHLER (17): I) all or almost all the sori fail to develop; II) the great majority of sori are abortive, intact ones being found only on the upper leaves and portions of the stem; III) most of the sori are intact on the upper leaves and mid-stem region of the full shoots; and conspicuous necroses are restricted to the stem base and lower leaves; IV) the sori are predominantly intact and extensive necroses are confined to lower leaves; V) necroses are barely perceptible but all or nearly all the sori develop completely. HEY (14) established a six-grade scale of infection, taking as a criterion the weight ratio of fresh excrescences to the proportion of sound tubers. Grade 0 refers to the complete lack of excrescences and Grade 5 to the maximum extent of excrescences.

incubation were made at the same temperature. The optimum incubation temperature is determined mainly by the requirements for the development of the potato shoot, whereas the infection temperature by the requirements for the development of the parasite, such as for the liberation and swarming of zoospores, and their penetration into the host. It was observed [2] that at a low infection temperature of 16°-17° C., using warty tissue which had been cooled to 4° C. and then incubated at 20° C. as the inoculum, the variations in the grade of infection were much smaller.

SASS tried to answer the question whether biotype G is composed of many physiologic races through cultures derived from one single sorus. It is interesting to note that only one sporangium is found in a sorus of biotype G, whereas in biotype D, 2-9, mostly 4-5, sporangia are formed in each sorus (17). He succeeded in culturing the fungus from a single sorus but there was little success in producing infection. There was no different behavior observed between the single-sorus isolates, nor between the isolates derived from a single wart. SASS referred further to the scarce occurrence of necrosis produced by biotype G as mentioned by HEY (14). This finding is in accordance with experience with new wart biotypes. It is likely that besides the oversensitive reaction of the host, the necrosis is also due to the resistance to the penetration of the fungus. According to SASS this variation in the extent of necrosis depends on the compositions of the epidermis, the xeromorphic structure, and the age and stage of development of the potato shoot. Obviously the very early growth of the periderm in the new shoot is of importance in the production of necrosis.

[2] Unpublished data.

Phytosanitary Measures

In Germany the foci of potato wart biotypes are thoroughly checked by the competent plant protection service. It is aimed at a complete eradication of the new foci through the following measures: prohibition of growing varieties that are not biotype-resistant, establishment of a preventative belt around the foci, furthering of the development of biotype-resistant varieties.

With regard to the development of biotype-resistant varieties, some progress has been made in Germany. In addition to the Max Planck Institute for Breeding, there are also a few private breeders engaged in breeding varieties resistant to new biotypes. The percentage of approved biotype-resistant varieties will certainly increase in the next years.

Outbreaks of new biotypes are of no economical importance to the potato cultivation in Germany as a whole, as the foci are mostly outside the main potato-growing areas and are limited to small fields where potatoes are grown for home consumption. However, they are of importance to the cultivators concerned and biotype-resistant varieties will enable them to produce potatoes again to meet their own needs.

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Recent Observations on Plant Diseases in the Sudan

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THESE notes refer to diseases of cereals and other crops recently observed in the Sudan. Recent incidence of diseases of cotton has been described separately.[1]

The writer wishes to thank the Director and staff of the Commonwealth Mycological Institute for their assistance in confirming the identities of the pathogens discussed in this paper.

Sorghum (Sorghum vulgare)

Downy mildew, *Sclerospora sorghi* (Kulkarni) Weston & Uppal, attacked sorghum, millet, Sudan grass and wild species of *Sorghum* in the Gedaref and Kassala areas of the east central Sudan. The disease was noted on the Mugud, Wad Fahl, Feterita and Aklamoi varieties of grain sorghums, but doubtless other varieties were also attacked. It was often severe over small areas and must have caused considerable crop loss in some localities, since infected plants were stunted and either completely sterile or bearing only malformed, worthless heads. Leaves of infected plants were small, chlorotic and tended to stand stiffly upwards and outwards in a characteristic manner quite different from the normal rather drooping growth of sorghum plants. Dark necrotic streaks and much leaf shredding developed later as numerous oospores of the fungus were formed in long lines within the interveinal tissues of infected leaves. Downy mildew was most severe in wet areas with continuous high humidity, and where sorghum had been sown on the same land for several consecutive seasons, undoubtedly surviving between crops as resistant oospores in the soil.

In 1956 a severe outbreak of downy mildew occurred on the Wad Fahl variety of sorghum at the Gezira Research Farm, Wad Medani, in a plot which had been fallow for the two previous years; in 1953 parts of this plot had received heavy dressings of farmyard manure, possibly containing oospores of the causal fungus derived from sorghum fodder on which the animals producing the manure had been fed. An apparently similar increase of downy mildew following heavy application of farmyard manure has been reported from India.[2] In 1956 the disease was undoubtedly favored by the exceptionally high humidity prevailing during the rainy season (July-October) in most parts of the Gezira.

In the Sudan downy mildew of sorghum was first identified in 1953 and has since become fairly prevalent in the Gezira and central Sudan. Its future progress should be carefully watched since it can be very destructive in wet seasons.

Other sorghum diseases recently found and not hitherto known in the Sudan are the leaf-spotting diseases caused by *Helminthosporium sorghicola* Lefebvre & Sherwin, *H. rostratum* Drechsler, *Phyllosticta sorghiphila* Saccas, *Septoria? zeina* Stout, and *Leptosphaeria? sorghiphila* (Peck) Sacc.; little is known about these in the Sudan but they do not appear to be of economic importance at present.

Maize (Zea mays)

In a crop disease survey of the southern Sudan in November 1954, maize rust, *Puccinia polysora* Underwood, was found to be widespread and often caused considerable leaf withering of maturing plants. In the Sudan this destructive pathogen was first observed in 1952 at Roseires on the Blue Nile near the Ethiopian border.[3] Since it was not seen during a visit to the southern Sudan in late 1951, the pathogen probably arrived in this region in 1952-53 and has

[1] TARR, S.A.J. 1957. Recent observations on diseases of cotton in the Sudan Gezira. *FAO Plant Prot. Bull. 5*: 85-88.

[2] MUNDKUR, B.B. 1949. *Fungi and plant diseases.* MacMillan & Co., London. 246 pp. (see p. 83).

[3] TARR, S.A.J. 1954. Diseases of economic crops in the Sudan. I. Cereals. *FAO Plant Prot. Bull. 2*: 75-77.

since then become common west of the White Nile and as far north as Malakal in the central Sudan. Doubtless it will soon reach all parts of the country with suitable climatic conditions; as yet it has not been found in places with mean annual rainfall less than about 30 inches. The economic importance of maize rust in the Sudan is not accurately known. Severe attacks causing extensive withering of foliage occur in the wetter parts of the country, but all observations to date have been made on maturing plants and not on the young crop. Judging from severity of symptoms on maturing plants it seems likely that the disease causes appreciable loss, but the extent of this can only be assessed by detailed observations on the crop throughout the season. The cultivation of rust-resistant varieties of maize would be the only control measure likely to be practicable in the Sudan at present.

Other recently discovered maize diseases include leaf spotting caused by *Leptosphaeria patellaeformis* Passer. and *Phyllosticta* sp., neither of which seems to be of much significance.

Pearl Millet (Pennisetum typhoides)

Pearl (bulrush) millet in the Kordofan sands area of the west central Sudan has in recent years been affected by " asali " disease caused by *Sphacelia* sp., probably conidial stage of the ergot fungus *Claviceps*. This disease is spread by insects and air currents, infects the young flowers and converts them into sticky sugary honeydew (" asal ") which attracts insects and thus facilitates the dissemination of the fungus. The honeydew is at first pinkish and fluid but later becomes dark and solid, the flower ovaries being finally converted into hard, dark brown or black, rather irregularly shaped sclerotia or ergots which are usually somewhat curved and elongated. The germination of such sclerotia has not been observed and the ascigerous stage, presumably *Claviceps*, is not known. Apart from the grain losses caused by this disease, which can be considerable over small areas, infected heads are poisonous and on analysis by the government analyst were found to contain ergotoxine. Infected heads are easily recognized by the black sticky masses of honeydew on the heads, often present in large quantities, and should be destroyed by burning and on no account eaten by human beings or stock. The disease is probably favored by cool, humid weather but has not been investigated in the Sudan.

Ergots of *Claviceps* sp. were also found on the grass *Anthephora hochstetteri* several thousand feet above sea level on Jebel Marra in the western Sudan where climatic conditions are cooler and moister than in most parts of the country; no ergotoxine was present in these ergots. *Sphacelia* spp., often conidial stages of *Claviceps*, have previously been collected on various grasses (*Brachiaria*, *Pennisetum*, *Panicum*) in the wetter southern regions of the Sudan but in no case were true sclerotia present, possibly because the honeydew resulting from *Sphacelia* attack was invariably overgrown by the fungus *Cerebella andropogonis* Cesati which probably inhibited full development of sclerotia.

Rice (Oryza sativa)

Experimental plots of rice at Malakal in the central Sudan showed widespread wilting in 1956. The crop had been sown by drill in late June to early July and had produced a healthy even stand, being mostly varieties of swamp rice cultivated under irrigation. In late July and August many plants showed browning and withering of the leaves; some died but many began to recover in September, after having suffered a prolonged check to growth. The roots of affected plants were smaller than those of healthy ones but there appeared to be little foot rotting. Affected plants were smaller and would probably produce heads later, a serious handicap to the intended combine harvesting. This condition seemed to be a sudden and severe check to growth, perhaps resulting from adverse soil conditions, rather than due to a pathogen. It might have resulted from high soil alkalinity, perhaps combined with low nitrogen content. In French West Africa yellowing, poor growth and low yields of rice have been reported from soils with pH higher than 7.5 and nitrogen content less than 0.5 percent, such soils sometimes having a slightly toxic effect, probably due to accumulation of nitrites (B. Dabin, Archive No. 6, 1954, de l'Office

du Niger). Past analyses of Malakal soil have given pH values mostly between 8.5 to 9 and sometimes even higher, and nitrogen contents between 0.2-0.4 percent, but further investigation is needed to elucidate the nature of this condition.

Leaf spotting diseases caused by *Stagonospora oryzae* Hara and *Hendersonia? oryzae* Miyake have recently been observed in the Sudan but their economic significance is not known.

Sugar Cane (Saccharum officinarum)

Ring spot, *Leptosphaeria sacchari* van Breda de Haan, was found on a small sugar plantation in the southwestern Sudan and appeared to be causing slight leaf damage. It might become more significant if cane cultivation were extended in this area. Apart from this, no disease of cane is likely to be present; only small areas of this crop are at present cultivated in the Sudan.

Other Crops

In a visit during December 1956 to the southern Fung area, near the Ethiopian border, "red rust" caused by the parasitic alga *Cephaleuros* sp. was prevalent on citrus (orange, lime) and guava (*Psidium guajava*). The latter plant was sometimes severely affected, showing appreciable leaf withering, some leaves being almost completely covered with numerous circular patches of the alga. The patches were usually about 0.5 centimeter in diameter, at first light yellow and later becoming red to dark brown in color. Citrus was less severely affected than guava. *Cephaleuros mycoidea* Karst. occurs on cashew nut, coffee, mahogany and mango in the southern Sudan but has not been seen on citrus or guava.

Mango (*Mangifera indica*) was attacked by what appeared to be bacterial leaf spotting, caused by *Pseudomonas mangiferae-indicae* Patel, Moniz and Kulkarni, which occurs in India and South Africa but was not previously observed in the Sudan. The leaf lesions were characteristically angular and at first translucent and water-soaked, later becoming black and sometimes spreading along the veins. Leaf blotching of mango caused by *Pestalotiopsis japonica* (Syd.) Steyaert was observed for the first time in the Sudan.

Chillies (*Capsicum annuum*) were often severely affected by what appeared to be symptoms of a virus disease, consisting of light to dark green mosaic with much leaf distortion and reduction, severe stunting of the whole plant and marked shortening of the internodes at the top of the plant.

Perithecia of *Sphaerotheca fuliginea* (Schlecht.) Poll. were found on the weed *Acalypha indica* in the central rainlands area. Powdery mildew is also sometimes troublesome on sesame (*Sesamum indicum*) in this area and although perithecia have not been seen on this crop the pathogen may well be *S. fuliginea*, possibly surviving the hot, dry intercrop months as perithecia produced on *Acalypha* and other weeds. Perithecia of *Sphaerotheca humuli* (DC) Burr. were found on *Bidens bipinnata* in the Jebel Marra area several thousand feet above sea level, the first record of this pathogen in the Sudan.

Typical symptoms of tobacco leaf curl virus were found on perennial bushes of *Vernonia* sp. in the southwestern Sudan, probably a means by which the virus persists between successive tobacco crops in this area.

Recently discovered diseases of other Sudan crops include:

Tobacco brown spot. *Alternaria longipes* (Ell. & Ev.) Mason

Rust of pigeon pea (*Cajanus indicus*), *Uredo cajani* Syd. (possibly uredostage of *Uromyces dolicholi* Arth.)

Peach rust, *Puccinia pruni-spinosae* Pers.

Watermelon rust, *Puccinia citrulli* Syd. & Butl.

Leaf spot of oil palm (*Elaeis guineensis*), *Helminthosporium stilbaceum* (Moreau) Hughes

Leaf spot of okra (*Hibiscus esculentus*), *Alternaria tenuissima* (Fr.) Wilts.

Tomato leaf spot, *Stemphylium solani* Weber

Banana leaf spot, *Helminthosporium musae-sapientum* Hansford and *Cladosporium musae* Mason

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Plant Disease Situation in the United States[1]

Compiled by PAUL R. MILLER

Plant Disease Epidemics and Identification Section, Agricultural Research Service
United States Department of Agriculture

Aster Yellows Virus Affecting Strawberries in Arkansas

FULTON of the Arkansas Agricultural Experiment Station reports [2] that the aster yellows virus has been verified as the cause of the widespread severe outbreak of a disease in Arkansas strawberry fields in 1954. [3] The symptoms observed then were recognized as resembling the effects produced by the aster yellows virus in strawberry, but the presence of the virus in the diseased plants was not proved.

The disease occurred in all strawberry plantings examined in the spring of 1954. The virus did not seem to spread from diseased plants to healthy plants in the field, and since all infected plants finally died, the disease was self-limiting. In 1955 and 1956 relatively few plants were affected, in only a few fields.

Transmission of the virus and symptoms in inoculated plants. Aster yellows virus was readily transmitted from diseased to healthy plants by stolon grafts, stolon to petiole grafts, and by excised leaflet grafts. The only difficulty encountered was that diseased plants died so rapidly that sufficient time for a graft union was often lacking. The incubation period following a successful graft varied from 36 to 80 days.

Symptoms were first noted as a yellowing, cupping and stunting of new leaves. If the plant survived the initial shock, it persisted with dwarfed leaves and a multiple crown. The abnormal flower symptoms, so characteristic of the disease in the field, were rarely observed in the greenhouse following graft transmissions. Symptoms in the commonly used strawberry virus indicator *Fragaria vesca* (East Malling clone) were essentially the same, the plant being reduced to a multiple crown covered with dwarfed leaves. The symptoms were not readily distinguishable from those produced by the strawberry virus complex of mottle and epinasty.

Transmission was accomplished by dodder (*Cuscuta campestris*) from strawberry to periwinkle (*Vinca rosea*) and back to strawberry.

Midsummer field symptoms. During 1954 and 1955 all strawberry plants affected by aster yellows virus in the field had died by July. Evidence obtained in 1956, however, indicated that this virus may commonly be responsible for the death of plants in many fields during July and August.

Under the local name of "spot dying," the disease, characterized by a sudden wilting and death of the affected plants, is most commonly noted during late July or August. All plants connected to an infected plant by runners die, thus forming a spot of dead plants. When dying plants are first noted the roots are black and dead. No parasitic fungi or nematodes have been found to be consistently associated with the dying plants.

During August of 1956, spot dying was noted in a number of fields. In one case the disease was transmitted to healthy strawberry plants from plants in the first stage of wilting by leaf and runner grafts. Under greenhouse conditions symptoms were essentially the same as those of strawberry plants affected by the aster yellows virus from spring collections. The presence of aster yellows virus was confirmed by dodder transmission to periwinkle.

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[1] This report is based upon material submitted by Collaborators of the Plant Disease Epidemics and Identification Section, Agricultural Research Service, United States Department of Agriculture.

[2] FULTON, J.P. 1957. Aster yellows virus affecting strawberries in Arkansas. *Plant Dis. Reptr. 41*: 521-523.

[3] SMITH, H.E. 1954. New strawberry disease in Arkansas. *Plant Dis. Reptr. 38*: 630-631 (see *FAO Plant Prot. Bull. 3*: 8-9. 1954).

It is not known how much of the spot dying can be attributed to the aster yellows virus. FULTON is of the opinion that aster yellows virus is responsible for the major amount of spot dying for which there is no other obvious explanation.

Other diseases resembling aster yellows in strawberry. In the course of studying aster yellows in strawberries in Arkansas, FULTON noted several strawberry diseases which might easily be confused. An unidentified virus, which produced foliage symptoms in Blakemore and several other strawberry varieties resembling those of aster yellows, was encountered. It differed from aster yellows in having a shorter incubation period (four weeks), producing very mild symptoms or no symptoms at all in the indicator *Fragaria vesca* (East Malling clone) and in failing to produce any degree of phyllody of flowers.

As pointed out by SLACK *et al*, [4] summer dwarf, caused by the foliar nematode *Aphelenchoides besseyi* Christie, may have symptoms resembling those produced by the aster yellows virus. The symptoms of summer dwarf are most evident in the autumn, whereas aster yellows virus in strawberry has been noted most commonly in the spring and summer.

[4] SLACK, D.A., SEYMOUR, C., FIELDS, H., and FULTON, J.P. 1957. Summer dwarf of strawberry. *Plant Dis. Reptr. 41* : 398-401 (see *FAO Plant Prot. Bull. 5* : 174-175. 1957).

Outbreaks and New Records

Pakistan

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First Record of *Uromyces pisi*

DURING the winter of 1956-57, many fields of grass pea (*Lathyrus sativus*) cultivated as a fodder crop at Thatta, about 60 miles southeast of Karachi, were found to be infected by the rust *Uromyces pisi* (Pers.) Wint. On 29 January 1957 when the disease was first noticed, the average intensity of attack was only about 5 percent as determined on the basis of the modified Cobb's rust scale. By 21 February 1957, however, it increased to about 40 percent, causing considerable damage to the crop.

This is the first record of the occurrence of *Uromyces pisi* on *Lathyrus sativus* in Pakistan and India. This rust is widespread in Europe.

Peru

CONSUELO BAZÁN de SEGURA

Departamento de Fitopatología
Estación Experimental Agrícola de La Molina

Host plants of *Macrophomina phaseoli*

CHARCOAL rot caused by *Macrophomina phaseoli* (Maubl.) Ashby was first reported in Peru in 1950 on potted seedlings of sour orange (*Citrus aurantium*) from Chiclayo in the northern coastal part of the country. In 1955 the same fungus was found to cause severe damage to tubers of potato (*Solanum tuberosum* var. *andigenum*) harvested at the Agricultural Experiment Station La Molina. At the end of 1956 and during the first months of 1957 *M. phaseoli* was identified on beans (*Phaseolus vulgaris*), castor bean (*Ricinus communis*) and three-year-old trees of olive (*Olea europaea*) grown on the northern coast of Peru. On all five hosts the damage was of economical significance.

It seems that the prevailing conditions during the last few years on the coast were favorable to the development of this fungus.

Plant Quarantine Announcements

Austria

By a notice dated 22 June 1957, the Director of the Austrian Plant Protection Service, in anticipation of increased importation of peaches from South Europe, declares the Oriental fruit moth (*Laspeyresia molesta*) as a harmful plant pest, in accordance with the Plant Import Ordinance of 5 August 1954 (see *FAO Plant Prot. Bull. 3* : 45-46. 1954). The importation of shipments infested by this pest will be prohibited.

Norway

Two Royal Resolutions of 26 October 1956, published in the *Norsk Lovtidend* No. 39, 15 November 1956, refer respectively to measures for prevention of the spread of wild oats, and measures regulating the importation of pine trees and potatoes. Royal Resolution of 14 March 1952 governing the importation of potatoes (see *FAO Plant Prot. Bull. 1* : 63. 1953) is thereby repealed

Wild oat. Wild oat (*Avena fatua*) is declared a harmful weed. It is prohibited to import, keep for sale, dispose of or sell seed grain or other seed that has been found on official analysis to contain wild oat seed. The Ministry of Agriculture, however, may grant exemptions from this prohibition.

Pine. The importation of pine plants from the U.S.A. and Canada is prohibited in order to prevent the entry of western pine gall rust (*Cronartium harknessi*).

Potatoes. For importation of potatoes, an import license must first be obtained from the Ministry of Agriculture and for this purpose the importer must submit a detailed description for each consignment. The consignment must be accompanied by a certificate issued by the Plant Protection Service of the country of origin not more than 14 days before the potatoes are dispatched, specifying the district where the potatoe swere grown and the names and addresses of the sender and recipient, and attesting to the following facts:

1. that the potatoes were actually grown in the exporting country where Colorado beetle (*Leptinotarsa decemlineata*) does not occur;
2. that the potatoes were grown in a district which is believed to be free from potato wart (*Synchytrium endobioticum*) and that in case of seed potatoes the soils at the place of origin were examined and found to be free from cysts of potato root eelworm (*Heterodera rostochiensis*);
3. that the consignment was examined and found to be free from Colorado beetle, potato wart, ring spot (*Corynebacterium sepedonicum*) or potato tuber moth (*Phthorimaea operculella*); and
4. that potatoes are packed in new containers which should be lead-sealed by the plant protection service of the country of origin.

Potatoes for human consumption may only be imported directly from countries where the absence of Colorado beetle has been officially established, and they are subject to inspection upon arrival.

The importation of seed potatoes is subject to the following conditions:

1. provision of a declaration attesting that the potatoes were under official control during the growing season in the country of origin;
2. fulfilment of minimum requirements established by the Government Seed Material Board for seed potatoes;
3. fulfilment of requirements with regard to freedom from diseases; and
4. growing of such potatoes under quarantine during the first year.

In the case of seed potatoes imported for experimental purpose, the Ministry of Agriculture may grant exemptions from the restrictions mentioned above.

News and Notes

Desert Locust Situation, 1956/57

The FAO Technical Advisory Committee on Desert Locust Control at its Seventh Session held in Tangier 19-22 June 1957 reviewed the developments in the desert locust situation since the summer of 1956 as follows:

The summer breeding of 1956 was either on a reduced scale or absent throughout most of the summer breeding areas, but it was exceptionally serious in the Sudan and Chad Territory, and extended westwards into Niger Colony and south-eastern French Sudan. Despite active control measures, numerous immature swarms appeared in the Sudan and Chad Territory and in Niger Colony during September. These new swarms dispersed in three main directions: to northwestern Africa, to the southwestern territories of West Africa and to the Red Sea coastal areas.

The movement towards northwestern Africa began in late September in northern Niger Colony; swarms appeared in the Southern Territories of Algeria, western Mauritania and Spanish Sahara during October, and entered Ifni and southern Morocco from mid-October. From November 1956 to January 1957 swarms continued to drift northwards on a wide front between southern Morocco and western Libya, and in February considerable numbers of swarms invaded northern Morocco, the French Departments of Algeria and Tunisia. Control measures in all the north-western African territories considerably reduced the number of swarms present, particularly in Morocco and Algeria, where oviposition did not begin until late March 1957, and which was far lighter than expected. Further east in Tunisia, oviposition, which began in late February and was continuing in May, was however more widespread; in Tripolitania it was fairly extensive during late March and April. Widespread hatching occurred in Tunisia from late March to May and in Tripolitania from 1 May and control operations were in progress in June.

A somewhat unusual development was the invasion of the southwestern territories of West Africa, which began in late October 1956, and continued in November and December, when immature and a few maturing swarms spread westwards through northern Nigeria, southern Niger Colony, southern French Sudan and Upper Volta Colony. During December swarms became numerous in southwestern Mauritania and northern Senegal. There was a marked southward shift of swarms during January and February 1957, but in the meantime oviposition occurred in western Mauritania where scattered hoppers and hopper bands were reported between February and April over a vast area. Where accessible these bands were controlled, but fledglings appeared during March and April.

This southward movement resulted in desert locust swarms being recorded during the first quarter of 1957 in Senegal, Gambia, Portuguese and and French Guinea, Sierra Leone, French Sudan, the Ivory Coast, Ghana, Dahomey and Nigeria, and swarms of undetermined species in the French Cameroons. In April and early May these overwintered swarms, possibly supported by young swarms from the winter breeding in Mauritania, migrated northwards and eastwards into southern French Sudan, Upper Volta Colony, northeastern Ghana, and northern Nigeria, and in May entered Chad Territory, Libya and southern Egypt.

The usual eastward spread of the 1956 summer-bred swarms led to an invasion of the Red Sea countries between October 1956 and January 1957. Breeding on the coastal plains of Sudan and Eritrea, which occurred from mid-October to February, was kept under control.

On the east of the Red Sea, from late September 1956 onwards, when scouting in Arabia was resumed, scattered adult locusts and small swarms in all stages of maturity were reported on the coastal plains of Saudi Arabia and Yemen; extensive hatchings occurred from late September to early November, and some fledglings appeared during November and December. In late December there was a second influx of mature swarms into the Saudi Arabian tihama and the Mecca area where hopper bands appeared from late January 1957 to early March. Swarms began to spread to central Arabia from the second week of January, and extensive hatchings occurred in southern Hejaz in February and early March and south of the Great Nefud in late March; control was drawing to a close during May, but some escapes were reported. Swarms apparently moved into northern and northeastern Arabia in early March, and in late April swarms in all stages of maturity were reported across north central Arabia reaching the Persian Gulf by the end of April, when oviposition began in the Riyadh and Qassim areas, where widespread hatching was reported during May. In May some breeding also occurred in Asir. In June hoppers were reported in Hofuf. The appearance of some mature swarms in Hadramaut and Muscat in May suggested the possibility of further unrecorded infestations in south central desert areas.

Some swarms, possibly from Arabia, reached eastern and central Sudan and Egypt in May.

In eastern Africa, populations of scattered adult locusts and hoppers and small groups were reported during the winter from many localities in the Somaliland Protectorate, particularly in the northwestern lowlands. From late April to early May 1957 several medium-sized laying swarms appeared in northwestern Somaliland Protectorate and southeastern French Somaliland; gregarious hatchings began in early May, and both adult swarms and hopper bands were augmented by insects from the heavy local scattered populations. Control operations were in progress in June.

British East Africa and the northern Near East territories remained clear of locust swarms throughout the period under review.

In the Indo-Pakistani area very local breeding was controlled during August 1956 in Rajasthan where scattered locusts were reported in considerable numbers in early November. Apart from unconfirmed reports of swarms in Baluchistan in September and October 1956, locust populations in Pakistan were low until mid-February when a small mature swarm was reported in northwestern Baluchistan; during April and May the scattered locust population increased and in May some hopper bands were controlled.

The Committee concluded that the situation was critical in the following four areas:

a) Tunisia and Tripolitania, where extensive breeding was in progress and new swarms were due to develop shortly;

b) Chad Territory and Sudan, where many swarms were available for summer breeding;

c) Central and Southern Arabia, where belated widespread breeding was taking place, possibly extending to inaccessible areas;

d) Somali Peninsula, where the breeding in progress might be intensified as a result of new invasions.

The Committee stressed that the general locust situation had deteriorated greatly in comparison to the same period in 1956, when only the Sudan-Chad area was seriously infested. The extend of the infestation there had proved too great for the local anti-locust forces and, in spite of their efforts, many swarms escaped, leading to a general recrudescence of the plague. A further factor contributing to the present extremely critical situation was the prolonged and very widespread spring breeding in Arabia, where it may have extended over areas difficult of access for the control forces.

There was no doubt that the regression of the plague in 1956 had been short-lived and a further spread of infestations over the whole desert locust area was to be expected during the coming months.

Information was received in early August that a very severe invasion from the west was in progress in the summer breeding areas of the Sudan.

Roma - Tip. del Senato del dott. Giovanni Bardi